1883

The systems of amalgamation

Floyd Davis

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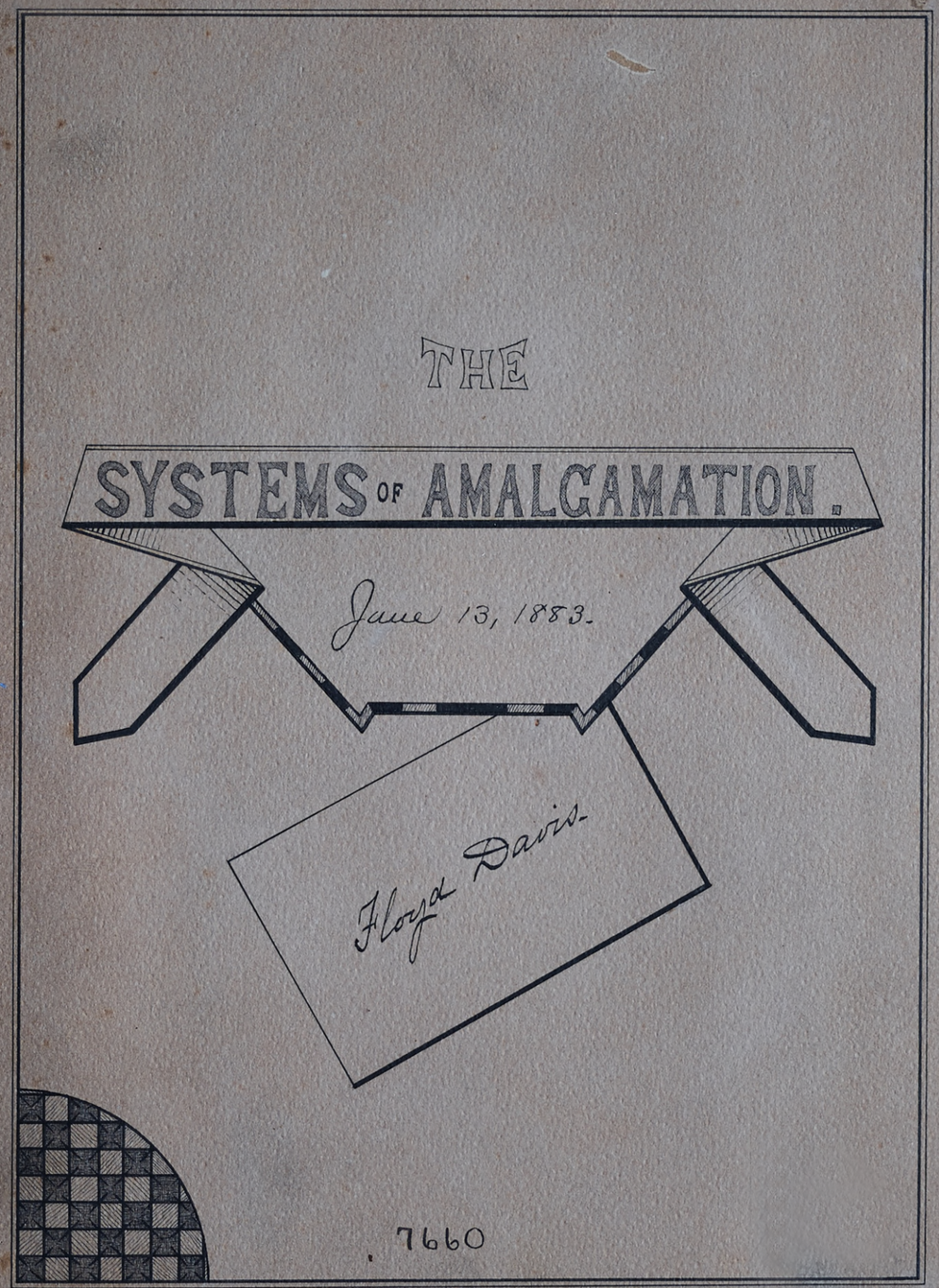

The Systems of Amalgamation

June 13, 1883

Floyd Davis

Rolla, Missouri, May, 1883.

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Mining

Mineralogists have shown that gold, with few exceptions occurs in the metallic state, disseminated in veins or scattered throughout alluvial deposits of old river basins. Silver is quite similar in its occurrence, but it is almost universally found in combination with other elements. The manner in which these metals occur forms a large factor in determining the most economical and efficient system of metallurgical treatment.

The theory of the formation of veins shows that the precious metals originally occurred in lodes, being deposited there either from injection from below or from infiltration from above; and from these the great valley deposits have been formed. The name “vein” has been given to the original formation

containing the gold and silver, and "placer deposit" to the latter. For the treatment of ores from the former, three great systems of amalgamation are principally used, and for the latter the modern methods of placer and hydraulic mining.
In California and Oregon where water supply is abundant, hydraulic mining is found to be the cheapest method for securing gold and silver.
Statistics show that the relative expense of mining placer deposits by hydraulic power, in sluices and in toms, and by hand, in cradles and in pans, is as 1:20:100:400.
But the securing of gold and silver, in toms, sluices, and riffles, as is done in hydraulic operations, really forms no true system of amalgamation. In the milling of ores from veins, however, the operations require

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perfection in order to secure profitable results; and for these, the Patio, the Freiberg, and the Washoe are the only processes deserving the name of system, though modifications of these are in vogue.

Patio Process

The Patio system of amalgamation is carried on principally in Mexico; the Freiberg System, in Germany, and on the Pacific slope for 1st class ones; while the Washoe System is used extensively for the extraction of gold and silver from 2nd and 3rd class ores from the great Comstock lode, in Utah, Nevada, and California.

The Patio system dates back to 1557, at which time Bartolemé de Medina, of Pachuca, Mexico, discovered that gold and

silver can be extracted from their ores
by the use of mercury, common salt,
and copper sulphate, without the agency
of heat. Until recently, this system
was the only one used in Mexico, but
the capitalists are now introducing American
Mills, and they are gradually abandoning the
Patio in the favor of ours.
Mexico is the second silver producing
country in the world; and even now about
seven-eights of the products come from the
Patio system. In this process, the ores are
ground in arastras; mixed with common
salt and copper sulphate; tramped on by
mules in open courts until the silver is
partially converted into a chloride; amalgamated
in open vessels; and then the amalgam
is strained and retorted for the precious
metals.

But the ores used in this system are remarkably free from gold, and many of the silver veins in Mexico are found to contain not even a trace of this element.
An average sample from the Santa Brigida vein, in Mexico, shows the following analysis:

Ag_2S	= 00.15	%
FeS_2	= 26.52	"
PbS	= 02.07	"
As_2S_3	= 00.10	"
ZnS	= 05.00	"
$FeSO_4$	= 00.25	"
$CaSO_4$	= 00.43	"
Mn_3O_4	= 03.54	"
$CaCO_3$	= 04.18	"
$MgCO_3$	= 00.96	"
SiO_2	= 50.00	"
H_2O	= 6.80	"
	100.00	

Like any process of free amalgamation, the Patio is unsuccessful with ores containing FeS, PbS, CaS, FeS_2, As_2S_3, and Sb_2S_3, but ZnS is especially unfavorable. These ores and the concentrated residues are generally sent to establishments in San Francisco, or others in Germany, where they are frequently treated by the lixiviation process of Ziervogel.
But for auriferous and argentiferous sands and ores containing free gold and silver, this process has given excellent results.

Mr. Richard E. Chism, of San Dimas, Durango, Mexico, in a paper to the Inst. of Mine Engineers, read August, 1882, says: "The silver obtained by the Patio process is almost entirely free from the baser metals and from impurities of any kind. An assay of several bars gave an average of $\frac{994}{1000}$ of silver and $\frac{3\ 1/3}{1000}$ of gold, leaving only $\frac{2\ 2/3}{1000}$ for the

baser metals, dirt, and loss. From 70 to 75% of the assay value of the ore in silver, can be extracted by careful working, though the ordinary amalgamators do not get over 72%. Some amalgamators claim that they can save 80% of the assay value, but this is extremely doubtful. Of the gold in the ore, at least 40% is lost; about 20% of the remainder goes with the silver, and the rest is recovered from tailings, or is caught in the tahona."

The 80%, however, can only be secured from ores tolerably free from sulphur and such as contain the silver in a free state. Even as low as 35 to 45% of the assay value is not uncommon in sphalerite ores.

The following is the average expense of working a ton of ore worth $60, as given by Mr. Chism:

Breaking	$1.53
Grinding	1.40
Scraping tahona	.13
Carriage of slimes from tahona to patio	.60
Cost of hired mules	1.73
Labor	1.80
Salt	2.80
Copper sulphate	1.33
Charcoal for roasting and assaying	.33
Mercury	4.68
Salary and gen. expenses	6.66
Repairs	2.33
Concentration of residues	2.26
Total	$27.58

In this process there is a great mechanical loss of mercury, silver, and especially gold. Much of the silver in Mexican ores is in

the form of sulphide, and a large part of the unrecovered mercury is used in reducing this. Mr. Napier, of the Guanaxuato reduction works, has made a series of experiments to ascertain the loss of mercury in ores containing chloride and sulphide of silver; and his results indicate that part of the unrecovered mercury is transformed into mercurous sulphide and chloride, during the reduction of the unconverted sulphide of silver and the chlorides formed in the patio. At least two-fifths of the gold passes into the residues, and if not sent elsewhere, is lost; but fortunately the amount is so small in these ores that no material loss is sustained by the mining companies.

This is a system that requires constant and careful attention lest the frequent handling of the mercury and amalgam

necessitates unprecedented loss.
The plants are often so unprotected that an additional force is required to protect the products, or else the companies sustain frequent plunder.
At least four weeks' time are required for the complete extraction of gold and silver, and this is frequently lengthened even to months, under variations of temperature. It may be said that the only advantage of this system is its cheapness of plant, and the unscientific talent required to manage the operations.

Freiberg Process

In 1780, a process of amalgamation, differing from that of Medina, was suggested by Baron de Born, of Venice, in which he

substituted copper kettles for patios in which amalgamation took place. Mr. Gellert soon suggested the use of tubs for the same purpose; and finally Ruprecht, of Halsbrücke, near Freiberg, in 1790 suggested the use of barrels. In this year the first works were erected at Freiberg, but they were soon consumed by fire, and it was not till 1794 that the Freiberg System of amalgamation was fairly tested.

This process is especially suitable for ores running high in gold and silver, even though they contain a large amount of As_2S_3, Sb_2S_3, ZnS, PbS, CuS, and FeS_2.

This differs from other true system of amalgamation, inasmuch as the ores are subjected to a process of roasting with common salt before being brought in contact with mercury.

In the Comstock lode, the ores are divided into three classes: 1st, those valued at $150 per ton, and over; 2nd, those from $90 to $150; and 3rd, those less than $90 per ton. Economically considered, it has been found most advantageous to treat 1st class ores by barrel amalgamation, and the 2nd and 3rd classes by the Washoe process.

But Mr. J. D. Hague, in his report on the treatment of Comstock ores in 1870 says that the quantity of high grade ore was there so small that one establishment controlled by Mr. J. H. Dole, in the Washoe valley had more than ample capacity for treating these ores.

The ores of the Pacific slope are first run through Blake crushers, and then through stamp mills. The first class

ores are then mixed with common salt; roasted in reverberatory or Stetefeldt furnaces until the silver becomes a chloride; then introduced in revolving barrels with mercury and iron; the mercury forms an amalgam with the gold and silver; is collected and strained, and finally retorted for the precious metals.

For this process it is essential that iron sulphide should form a large constituent of the ore; in roasting, it oxidizes to iron sulphate which reacts on the common salt, forming in the presence of oxide of iron, chloride and hydrochloric acid gasses, which convert the silver and part of the gold into their respective chlorides. Metallic iron now reacts on these, forming chloride of iron and liberating the gold and silver. The constant agitation of

the ore in barrels with mercury, converts the precious metals into amalgam which is secured from settling tanks.
Gold requires friction and silver chemical action, for the former is generally free while the latter is combined and requires liberation before amalgamation can be effected.
This process is said to yield at least 80% of the assay value of the ore, but the general expense of treatment is extremely high. Mr. Hague reports that the expense of treating the 1st class Comstock ore, in 1870, ranged from $40 to $45 per ton, but this came mainly from the high price of fuel and labor, where even now wood costs $5.00 per cord, and labor $4.00 per day. But since the introduction of the Stetefeldt furnace, expenses have been considerably reduced.

The cost of roasting a ton of ore in a reverberatory which averaged then about $21, can now be done for $5.00 or $6.00 in the Stetefeldt furnace. This reduces the general expenses of treating 1st class ores to $20 or $30 per ton. Mr. Phillips says that an ore from the Ophir Works, in Nevada, which assayed $80, cost $20.14 per ton for metallurgical treatment. This had been even as high as $27 where a large amount of salt, mercury, and time were required.

This system of amalgamation is undoubtedly the most perfect, but its expensive outfit and management prevent its use except for high grade ores.

A large loss of mercury is always necessitated in this process, ranging from ¼ to ½ the weight of gold and silver produced,

and is mainly due to the formation of calumet, and the unrecovered mercury scattered throughout the pulp in minute particles.
The presence of lead and copper in the ore tends to increase this amount of loss by reducing their chlorides which are formed during the process of roasting. The lead and copper thus liberated pass into the amalgam and give it a spongy consistency, which after retorting render cupellation necessary in order to free the gold and silver of these and other base metals.
In the complete process, from 5 to 8% of the silver is volatilized as an acid, when treating rebellious ores.

Washoe Process.

The gold and silver mines west of the Rocky Mountains supply an ore which is generally quite uniform in character and value. But in a few localities an extremely valuable ore has been found, and Mr. Phillips says that 80 tons assaying $2200 were taken from one pocket. Still the great mass of ore of the Comstock lode ranges from $35 to $70 per ton, and for this, the Washoe System, which derives its name from the valley in which it was first used, has been found remarkably suitable.
It is a system of free milling, and the ores most suitable are native silver and gold, chloride of silver, and certain forms of sulphide of silver.
It often happens that the upper part of silver veins is free milling, owing to the

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Washoe Process

disintegrating influence of water and air;
while in the lower parts the sulphides
need to be roasted before being
milled. And it sometimes happens that
sulphuret ores are free milled
owing to the cheapness of this process, where
the increased percentage of gold and silver
would not pay the extra expense of
roasting.
On one hand it was found that the
expense arising from roasting ore in the
Freiberg process was so great that only a
small margin, if any, would remain as
profit; while on the other, the inefficiency,
length of time, and cost of labor,
of the Patio system were equally undesirable.
Experiments were then made by amalgamating
in pans with common salt and copper
sulphate, and the results were so satisfactory

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ing that in 1859 large establishments
for this process were erected near Virginia
City, Nevada.

This system has since been adopted for
the greater part of the Comstock ores.
In it, these ores are generally pulverized in
Blake crushers and these stamped in
batteries containing amalgamated copper
or silver plates which secure a large
part of the gold and silver. The ores are
washed over blankets and riffle plates
as they pass from the stamp mill, which
again secure a further amount of the
desired metals; and finally the heavier
part of the ore is secured in settling
tanks, from which it is taken to the
amalgamators and subjected to further
treatment. Here it is treated in pans
with mercury and chemicals for a few hours,

and from these it passes successively into agitators, settlers, and precipitating tanks. The amalgam is here secured and retorted for the gold and silver.

The efficiency of this system depends principally on the amalgamation which goes on during the process of attrition, and for the thoroughness of this, various designs of pans have been used, but those proving most desirable are, perhaps, the Varney, the Wheeler, and the Peterson.

The chemical reactions which take place in this process have not been agreed upon by chemists, but Mr. J. D. Hague has made more extensive investigations on this subject than anyone else, and his conclusions will be of interest here.

In his report of Mining Industry of the Comstock ores, page 293, we find

1st. That the ores consists chiefly of native gold and silver, with sulphide of silver mixed with blende and galena.

2nd. That common salt and copper sulphate produce in the pan the chloride of copper.

3rd. Both cupric and cuprous chlorides assist in reducing the ore by chlorinizing the silver.

4th. Copper sulphate which is formed in the process augments the amalgamating energy of the mercury and also tends to remove lead from the amalgam.

Experiments have also been made without using chemicals, and the process thus modified, has in many cases given equally good results.

The plant for this system of amalgamation, like that of the Freiberg, is quite expensive, but the simplicity and cheapness of the

operations render the process more desirable for the great mass of ore in the West, and it is, perhaps, the most successful of any of the systems of amalgamation. The climate of California and Nevada is remarkably favorable for the chemical reactions of this process, and equally as unfavorable for those of the Patio.

In ordinary cases the results for silver are from 65 to 70% of the assay, while about 90% of the gold is secured, but when the residues have been re-amalgamated, 85 or 90% of the silver is sometimes obtained.

In the Washoe Valley the cost of treatment ranges from $5.00 to $6.75 per ton, and if the tailings are re-amalgamated, the additional expense is, perhaps, $5.50.

Cost of outfit, labor, and kinds of ore, figure largely in the expense, and this is

controlled by locality.

As reported by Mr. W. Lawrence Austin, to the Inst. of Mine Engineers, the expense has been greatly reduced in Arizona. He says that the expense per ton of ore is:

For fuel	$1.05
" chemicals and mercury	.77
For lubrication	.04
" illumination	.03
" casting	.33
" supplies	.16
" labor	2.52
Total	$4.90

The bullion produced by this process is generally very pure, saying from 970 to 997 fine and is mainly due to some chemical action, perhaps, that of copper sulphate in removing the lead incorporated in ordinary amalgam.

In this process the loss of mercury is largely mechanical, for it has been experimentally shown that only a small amount of mercury enters here into chemical combination.

Sodium Amalgam

The use of sodium is found to greatly enhance the energy of mercury for dissolving the precious metals. The priority of this discovery is disputed, but the claimants were undoubtedly independent in their investigations and without knowledge of each other's work. Dr. Wurtz, of New York, applied for a patent in 1864, and Mr. Crookes of England, in 1865.
For ores containing certain compounds of sulphur, arsenic, and tellurium, the use of sodium amalgam will prevent the

flowering of mercury. And when coatings of sulphides, oxides, and even grease are found in gold and silver, the use of this amalgam is very efficient. It is becoming quite extensively used and the extraction is far more perfect especially if the ores are sulphides, than by the use of mercury alone.

In some of the mines of the Black Hills, the free milling ores are treated by stamping in batteries containing this amalgam and allowing the pulp to flow over amalgamated plates. This is the cheapest method for securing gold and silver by amalgamation, and it is said by Fraser and Chalmers that in some of the best establishments the expense is only 80 cents per ton.

Sulphide Ores.

If the gold and silver were free in all ores, amalgamation would be tolerably perfect in any system, but even with the best processes there is always a great loss; and the inefficiency seems to be due mainly to the condition of the gold and silver in sulphide ores. Chemists and metallurgists tell us that gold in sulphide ores is in the metallic state; and experiments have shown in a large number of cases that it is in an extremely fine state of division, either in minute particles scattered throughout the mass of ore, or in thin films surrounding the faces of crystallization.
In order then to extract the precious metal, the ore must be rendered a pulverulent mass, which is often done by stamping, but when this is secured, the buoyancy of the

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water running form the battery carries away
a large part of this microscopic gold.
The recent experiments of Mr. Melville Atwood,
recorded in his "Microscope in Metallurgy"
indicate that much of the loss in amalgamation
is due to stamping. He says:
"In amalgamation in the batteries, unnecessary
dead stamping causes some of the amalgam
to be battered and converted into a black
mass, becoming mixed with the baser mineral,
particularly so, should a small quantity
of zinc get into the mercury, the
magnetites and waste iron from the wear
of the shoes, &c., would be coated with
mercury; and the amalgam thus sickened,
a large portion of it will pass over the
silvered plates. I find the battery pulp,
even without mercury in the batteries, but
where a large proportion of pyritic matter

is being treated, to have a decided acid reaction, due in a great measure to the presence of ferric and ferrous salts, soluble in water. The former of these salts destroys the action of quicksilver, enfilming it with a compound insoluble in water, and preventing that metallic contact taking place between detached mercurial globules so necessary to amalgamation."

Perhaps three reasons may thus be assigned why amalgamation has proved unsuccessful with this class of ores:

1st. Because much of the gold is too finely divided to be brought in contact with the mercury____ it floats off in the upper currents running from the stamp mill.

2nd. In many sulphide ores, a thin film of sulphide, oxide, or siliceous substance

has been observed facing the films of gold, and it may be quite impossible to separate these by the ordinary operation of stamping. Sodium amalgam has to a certain extent obviated this difficulty.

3rd. The gold when in so finely a divided state, may, perhaps, be made passive to the action of mercury.

It is safe to say, however, that the sulphides retain their gold and silver to a greater extent than those ores destitute of this element; and by roasting and volatilizing the sulphur and perhaps some arsenic and antimony, if present, a far more perfect amalgamation can be made.

Mr. J. Latta, of New South Wales, reports the following results from experiments made on natural and roasted ores:

From twenty tons of raw sand, containing 3.3 ozs Au per ton:

Gold obtained by amalgamation	29.21 %
" " from tailings	42.84 "
" carried off in water	27.95 "
	100.00 "

From twenty tons of roasted sand, containing 1.38 oz. Au per ton:

Gold obtained by amalgamation	51.57 %
" " from tailings	27.21 "
" carried off in water	21.22 "
	100.00

These experiments indicate that in the unroasted ore only a small part of the gold was secured by amalgamation, while a very large part passed off in the tailings.
In the roasted ore, more than one-half of the gold was secured by amalgamation, or nearly twice as much as from the natural, while in the tailings about two-thirds as much passed off as from the natural

sample. In both cases a large amount escaped in the water, but still only about three-fourths as much from roasted as unroasted ore.
In many mills in the West which treat these ores, concentrators are attached to the battery, and the extra expense of treatment is very little indeed, as the mechanisms are generally automatic and require little power.
But to obviate the difficulty arising from the metallurgical treatment of auriferous sulphides is a problem remaining not yet fully solved. And the only way in which satisfactory results are secured is by treating the ore at least a second time.
The residues which come from the amalgamation are generally re-amalgamated or subjected to chlorination.
In the Boston and Colorado Smelting Works,

during three years, gold ore assayed .694 oz. and the tailings .183 oz. per ton.
On Comstock ore, the Varney and Hepburn pans under favorable conditions only secure about 70%, and if the same operation is continued half-a-dozen times, not more than one-third of the remainder is secured.
Prof. John A. Church says "With all the advantages of twenty years in milling, there is nothing more crude in metallurgy than the treatment of tailings in many of the larger mills of the West."
Perhaps the most perfect amalgamation has been secured in the prospector's pan, and on the principle of its construction several improved concentrators and amalgamators have been made for treating residues from the Washoe process.
Among the most important may be mentioned

the Paddock concentrator, and the Peck amalgamator.

In preparing the residues for concentration, they flow over a series of screens, graduated in mesh, so that the particles of mineral are gangue and separated into groups of various sizes, each separate size being treated in a distinct jig.

The Paddock is an air concentrator, consisting of a sieve upon which the sized ore is thrown and a current of air is introduced from beneath. The lighter particles are blown away, leaving only the heavier parts containing the gold and silver; thus a separation is made by means of specific gravity. The cost of concentration ranges from $1.20 to $2.50 per ton of ore.

The Peck amalgamator consists of a pan or a series of pans, similar to the prospector's,

which are made to revolve much the same
as done by hand.
These processes have also been used for the
treatment of raw ores. In the Blue Hill
Mine, in Maine, the gold and silver are
extracted by first concentrating the ore,
and the tailings are said to contain only
from seven-tenths of an oz. to one and one-fourth
oz. per ton.
In raw amalgamation of tailings and slimes
about 5 lbs. of copper sulphate and from
20 to 30 lbs. of common salt are added
per ton. From this the result is said
to be about 60% of the assay value for
tailings, and sometimes as high as 80%
for slimes. The expense per ton of tailings
has averaged:

For labor	$1.40
" mercury	0.95

For chemicals $1.33
" fuel 1.20
" casting .12
" incidentals .60
Total $5.60

And for slimes the expense is, perhaps, twice as much, owing to different circumstances. No less than 5 lbs. of mercury are lost per ton of slimes, and even with these expenses, a saving of $4co per ton has been secured from some parts of the Comstock ore. Sometimes the tailings are passed over blankets for concentration, and a product often averaging $25 per ton is secured, perhaps getting 50% of their value. This is then amalgamated in pans and a yield of some 60% is secured, thus making about 30% of the total value extracted.
In some localities the tailings and slimes

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In some localities the tailings and slimes

were formerly roasted before being amalgamated,
but this expensive method has
long since been discarded, except when
the Stetefeldt furnace is used.
The slimes from some of the rich sulphide
ores in Colorado are said to assay as
high as $50 per ton. The expense of
amalgamation when roasting these is about
$12 per ton, and the yield 70%.
In many gold districts, however, the residues
have been allowed to settle in large pits,
which yet remain unworked. Statistics
show that some of these, for example,
the Carson reservoir, assays form $7.00
to $13.00, and some even as high as $18.00
per ton.

Chlorination Process.

The Chlorination Process is, perhaps, the most efficient for the final treatment of tailings and slimes, and it has often been used for the treatment of auriferous sulphides.
This was the invention of a Mr. Plattner, who used it first at Reichenstein in Upper Silesia, about the year 1851. In this locality large quantities of arsenical and copper pyrites accumulated till the mining of galena was abandoned about the beginning of the 17th century. These by-products were first worked for arsenic, leaving the auriferous residues, which were unprofitable whether worked with lead or treated by amalgamation; and it was not till they were treated by chlorination that profitable results were secured.
The process consists in roasting the ore

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The process consists in roasting the ore

either in a reverberatory or Stetefeldt furnace
until all the sulphur, arsenic, and antimony
are volatilized, and the copper, iron, zinc,
and lead are converted into oxides.
The ore is then removed to large vessels where
chlorine gas is introduced and allowed to
remain until the gold and silver have been
converted into chlorides. Gold chloride thus
formed is soluble in water, and is filtered
off into large carboys, from which filtrate
the gold is precipitated by ferrous sulphate
iron, or sulphuretted hydrogen. This is
collected and fused in large crucibles.
The silver chloride yet remains in the mass
of ore. A hot solution of common salt is
now added in the tank; the silver chloride
is rendered soluble in this, and is caught
in large vessels, from which it is reduced
and precipitated by copper.

Modern experiments have shown that the best results are secured when the chlorine is in the ore under pressure and at a moderate temperature, and for improvements of this kind, several modifications of Plattner's method have been patented.

This process is well known to metallurgists as the cheapest and most perfect for the treatment of auriferous sulphide residues when the gold is finely divided. With these even where the methods of Augustin, Ziervogel, and Von Patera have failed, chlorination has worked with profit.

Nor is this method confined to residues only. It has been introduced by Kustel and Hoffman for the metallurgical treatment of certain silver ores. It has also been extensively used for the treatment of the auriferous sulphides of Colorado, and with

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good results.
The most perfect chlorination has been obtained:
1st. When gold and silver are finely divided and in the metallic state.
2nd. When there are no metallic sulphides present.
3rd. When there is no free hydrochloric acid present.
The first is indispensable, for chlorine gas only works energetically on uncombined metals. It is stated by Calvert that chlorine in the nascent state is most effective; this has been shown by liberating the gas in the mass of ore by treating MnO_2 with HCl. The sulphides and sulphates must be roasted till the sulphur is volatilized and their bases and other metals are converted into oxides. If not volatilized,

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3rd. When there is no free hydrochloric acid present.
The first is indispensable, for chlorine gas only works energetically on uncombined metals. It is stated by Calvert that chlorine in the nascent state is most effective; this has been shown by liberating the gas in the mass of ore by treating MnO_2 with HCl. The sulphides and sulphates must be roasted till the sulphur is volatilized and their bases and other metals are converted into oxides. If not volatilized,

unnecessary chlorine will be consumed in forming chlorides, which will be soluble and then be re-precipitated with the gold, if sulphuretted hydrogen is used. Sulphur, if present, also tends to form a chloride of sulphur, which breaks up into HCl and H_2SO_4; these bring into solution undesirable bases.

The chlorine gas is generally purified in order to recover all HCl, which not only brings into solution the bases, but also forms H_2S, if all the sulphur has not been volatilized, and this re-precipitates the gold before it is recovered from the ore.

Kerl says that lime in the ore increases uselessly the consumption of chlorine, and causes a variable yield of gold.

It is said that auriferous pyrites can be

worked with profit, even if there is not more than .01% of gold, if a large part of the iron, copper, and zinc are previously removed with H_2SO_4.
But in this work a moderate temperature must be secured, for a high heat reduces the chloride. $AuCl_3$, when heated to 200°C becomes Au Cl, and thus into Au at 240°C.
The expense in a chlorination establishment comes not from the chemical process itself, but from the roasting of the ore.
The ores are generally roasted in reverberatory furnaces. The high price of fuel, in mining regions, has been the greatest obstacle against the chlorination process.
In Colorado, it was thought, previous to the introduction of the Stetefeldt furnace, that ores yielding less than $15.00 per ton would not pay for chlorination.

But since this furnace has been introduced, ore can be roasted for one-third the original cost; and the present expense for complete treatment is from $8.00 to $10.00 per ton.
Gold from this process is, perhaps, purer than from any other of the metallurgical operations; on an average it is about 995 fine.
Raymond, in his report of 1870 says: "Although the extraction of silver and gold separately is more perfect than by pan amalgamation, the resulting metal finer and the process cheaper, there are at present two reasons that pan amalgamation is preferred. While the amalgam is obtained in five or six hours from the pan amalgamation, by a treatment which is the simplest of all metallurgical

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logical operations, the chlorination process requires 24 hours' time and more attention - Time and simplicity are the considerations - The chlorination process dispenses with the heavy investment for amalgamating pans and settlers, but it dispenses also with the superintendency of carpenters and engineers, a pet institution of most silver mining companies - The chlorination process is not in reality complicated - This obfection is imaginary and arises from ignorance of the process -"

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